TQMa28
User's Manual

TQMa28 UM 104
28.03.2013

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Revision history

Rev.	Date	Name	Pos.	Modification
003	18.03.2011	Petz		Document created
004	14.07.2011	Petz	Table 6 Illustration 15	Pin assignment revised Replaced
100	25.10.2011	Petz	All	Complete rework
101	03.11.2011	Petz	Table 19	Unit corrected
102	19.12.2011	Petz	All	Expression “Accumulator” replaced with “battery” Expressions containing the word “battery” stated more precisely
103	24.05.2012	Petz	Table 4 Table 6 Table 6 Section 5	Values of plating corrected Typo corrected: LDADC4 LRADC4 Negation removed: USB_0_PWR_EN, USB_1_PWR_EN Link to Wiki added
104	28.03.2013	Petz	4.2.8 3.1.2.1 All	Info concerning LAN8720 clarified Max. size of eMMC corrected Signal description of SD_WP and SD_DETECT# corrected

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1.5 Symbols and typographic conventions

Table 1: Terms and Conventions

Symbol	Meaning
	This symbol represents the handling of electrostatic-sensitive modules and / or components. These components are often damaged / destroyed by the transmission of a voltage higher than about 50 V. A human body usually only experiences electrostatic discharges above approximately 3,000 V.
	This symbol indicates the possible use of voltages higher than 24 V. Please note the relevant statutory regulations in this regard. Non-compliance with these regulations can lead to serious damage to your health and also cause damage / destruction of the component.
	This symbol indicates a possible source of danger. Acting against the procedure described can lead to possible damage to your health and / or cause damage / destruction of the material used.
	This symbol represents important details or aspects for working with TQ-products.
`Command`	A font with fixed-width is used to denote commands, file names, or menu items.

1.6 Tips on safety

Improper or incorrect handling of the product can substantially reduce its life span.

1.7 Handling and ESD tips

General handling of your TQ-products

	The TQ-product may only be used and serviced by certified personnel who have taken note of the information, the safety regulations in this document and all related rules and regulations. A general rule is: do not touch the TQ-product during operation. This is especially important when switching on, changing jumper settings or connecting other devices without ensuring beforehand that the power supply of the system has been switched off. Violation of this guideline may result in damage / destruction of the module and be dangerous to your health. Improper handling of your TQ-product would render the guarantee invalid.

Proper ESD handling

	The electronic components of your TQ-product are sensitive to electrostatic discharge (ESD). Always wear antistatic clothing, use ESD-safe tools, packing materials etc., and operate your TQ-product in an ESD-safe environment. Especially when you switch modules on, change jumper settings, or connect other devices.

1.8 Naming of signals

A hash mark (#) at the end of the signal name indicates a low-active signal.
Example: RESET#

If a signal can switch between two functions and if this is noted in the name of the signal, the low-active function is marked with a hash mark and shown at the end.
Example: C / D#

If a signal has multiple functions, the individual functions are separated by slashes when they are important for the wiring.
The identification of the individual functions follows the above conventions.
Example: WE2# / OE#

1.9 Further applicable documents / presumed knowledge

- **Specifications and manual of the used modules:**
  These documents describe the service, functionality and special characteristics of the used module (incl. BIOS).

- **Specifications of the used components:**
  The manufacturer's specifications of the used components, for example CompactFlash cards, are to be taken note of.
  They contain, if applicable, additional information that must be taken note of for safe and reliable operation.
  These documents are stored at TQ-Systems.

- **Chip errata:**
  It is the user's responsibility to make sure all errata published by the manufacturer of each component are taken note of.
  The manufacturer’s advice should be followed.

- **Software behaviour:**
  No warranty can be given, nor responsibility taken for any unexpected software behaviour due to deficient components.

- **General expertise:**
  Expertise in electrical engineering / computer engineering is required for the installation and the use of the device.

1.10 Acronyms and definitions

The following acronyms and abbreviations are used in this document:

Table 2: Acronyms

Acronym	Meaning
A/D	Analog/Digital
ARM®	Advanced Risc Machine
BGA	Ball Grid Array
BSP	Board Support Package
CAN	Controller Area Network
CPU	Central Processing Unit
DC	Direct Current
DDR	Double Data Rate
EEPROM	Electrically Erasable Programmable Read-Only Memory
eMMC	Embedded MultiMediaCard (Flash)
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
FR-4	Flame Retardant-4
GPIO	General Purpose Input/Output
IEEE®	Institute of Electrical and Electronics Engineers
IP00	Ingress Protection 00
I^2C	Inter-Integrated Circuit
I^2S	Inter Integrated Circuit Sound
JTAG	Joint Test Action Group
LCD	Liquid Crystal Display
LSB	Least Significant Bit
Mbps	Megabit per second
MMC	Multimedia Card
MSB	Most Significant Bit
MTBF	Mean operating Time Between Failures
NAND	Not-and
OTG	On-The-Go
PHY	Physical (Interface)
PWM	Pulse Width Modulation

Table 2: Acronyms (continued)

Acronym	Meaning
RMII	Reduced Media Independent Interface
RoHS	Restriction of (the use of certain) Hazardous Substances
RTC	Real-Time Clock
SD card	Secure Digital Card
SD/MMC	Secure Digital Multimedia Card
SDIO	Secure Digital Input/Output
SDRAM	Synchronous Dynamic Random Access Memory
SMD	Surface Mounted Device
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
SSI	Synchronous Serial Interface
TBD	To Be Defined
TTL	Transistor-Transistor Logic
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
WEEE	Waste Electrical and Electronic Equipment
WP	Write-Protection
WVGA	Wide Video Graphics Array (800 × 480)

2. BRIEF DESCRIPTION

The specification describes the hardware of the TQMa28, and refers to some software settings.

The specification does not replace the Reference Manual.

The TQMa28 is a universal Minimodule based on the Freescale ARM-CPU MCIMX287CVM4B (i.MX28). The ARM926EJ-S core works with up to 454 MHz. The module extends the TQC product range and provides a well-balanced ratio between computing performance and graphics power.

The module provides the following key functions and characteristics:

- Freescale i.MX287 (ARM9 architecture), 454 MHz
- All functional CPU pins are routed to module connectors
- Up to 32 GiB eMMC flash
- Up to 256 MiB DDR2 SDRAM
- 64 Kibit EEPROM
- 12 bit A/D converter
- PWM
- Various serial interfaces depending on multiplexing (UART, SPI, I^2C, I^2S)
- 2 × CAN
- Temperature sensor
- 2 × USB 2.0 Hi-Speed Host interface (only with 5 V supply)
- Extended temperature range on request
- Low power consumption (0.35 to 2 W, depending on mode of operation)
- Dimensions: 40 × 26 mm^2
- Long term available
- Single power supply: 5 V or 3.3 V (3.3 V: no USB)
- Power consumption in Standby mode[1]:

5 V	0.5 W
3.3 V battery powered	0.35 W

Since all functional pins of the processor (except SDRAM interface) are routed to the module connectors there is a wide range of possible applications for the TQMa28.

[1] All components of the TQMa28 are energized, no further activities.

3. TECHNICAL DATA

3.1 System architecture and functionality

3.1.1 TQMa28 block diagram

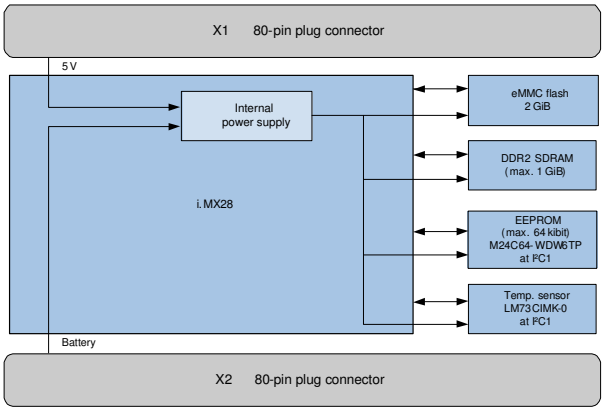

Illustration 1: TQMa28 block diagram

3.1.2 System functionality

3.1.2.1 System components

- Processor (Freescale CPU MCIMX287CVM4B, ARM926EJ-S, 454 MHz)
- Crystal oscillators for the CPU (24 MHz and 32.768 kHz)
- DDR2 SDRAM (16 bit, 133 MHz, 128 MiB)[2]
- eMMC NAND flash (up to 16 GiB)[3]
- EEPROM (via I²C, 64 Kibit)
- Temperature sensor (via I²C)

3.1.2.2 Interfaces

- 2 × 80-pin module connector

A detailed overview of all available users' interfaces can be found in section 4.1 on page 9.

[2] Standard configuration, other sizes of DDR2 SDRAM are optional.
[3] Standard configuration, other sizes of eMMC are optional.

4. ELECTRONICS SPECIFICATION

4.1 Interfaces to other systems and devices

The TQMa28 is connected to the carrier board with 160 pins on two module connectors.
The module is held in the connectors with a considerable retention force.
To avoid damaging the modules' connectors as well as the carrier board connectors while removing the module the use of an extraction tool is strongly recommended.

4.1.1 Module connectors

Table 3: TQMa28 module connector

Manufacturer	Order no.	Description
tyco	5177985-3	80-pin female connector, 0.8 mm pitch, vertical, –40 °C to +85 °C

In the following table the applicable carrier board mating connectors are listed.

Table 4: Carrier board connectors

Manufacturer	Order no.	No. of pins	Plating	Board to board distance
Tyco	5177984-3	80	0.2 µm Gold	5 mm
Tyco	5084614-3	80	0.76 µm Gold	5 mm
Tyco	5179029-3	80	0.2 µm Gold	6 mm
Tyco	5084615-3	80	0.76 µm Gold	6 mm
Tyco	5179030-3	80	0.2 µm Gold	7 mm
Tyco	1-5179030-3	80	0.76 µm Gold	7 mm
Tyco	5179031-3	80	0.2 µm Gold	8 mm
Tyco	6123002-3	80	0.76 µm Gold	8 mm

The board to board distance results from the height of the TQMa28 connector and the connector on the carrier board. The drawings of the TQMa28 can be found in section 6.
When using the processor signals the multiple pin configurations by different processor-internal function units must be taken note of.
The pins of the module connectors are described in detail in the following tables.
In addition to direction, pin name and pin number, external and internal pull-up or-down wirings as well as the references to I/O voltage and processor pin characteristics are listed.

4.1.1.1 Module connector X1

Table 5: Pin assignment module connector X1

PU/PD	I/O	Level	Usage	i.MX28 pin	Name	Pin		Pin	Name	i.MX28 pin	Usage	Level	I/O	PU/PD
		0V	POWER		GND	1		2	GND		POWER	0V		
	out	3V3	LCD	N1	LCD_DOTCLK	3		4	LCD_VSYNC	L1	LCD	3V3	out	
		0V	POWER		GND	5		6	LCD_HSYNC	M1	LCD	3V3	out	
	out	3V3	LCD	K1	LCD_WR_RWN#	7		8	GND		POWER	0V		
	out	3V3	LCD	M6	LCD_RESET	9		10	LCD_RS	M4	LCD	3V3	out	
	out	3V3	LCD	P4	LCD_RD_E	11		12	LCD_ENABLE	N5	LCD	3V3	out	
	out	3V3	LCD	P5	LCD_CS#	13		14	LCD_D00	K2	LCD	3V3	out	10 kΩ ↑
10 kΩ ↓	out	3V3	LCD	K3	LCD_D01	15		16	LCD_D02	L2	LCD	3V3	out	10 kΩ ↓
10 kΩ ↑	out	3V3	LCD	L3	LCD_D03	17		18	LCD_D04	M2	LCD	3V3	out	10 kΩ ↓
	out	3V3	LCD	M3	LCD_D05	19		20	LCD_D06	N2	LCD	3V3	out	
	out	3V3	LCD	P1	LCD_D07	21		22	LCD_D08	P2	LCD	3V3	out	
	out	3V3	LCD	P3	LCD_D09	23		24	LCD_D10	R1	LCD	3V3	out	
	out	3V3	LCD	R2	LCD_D11	25		26	LCD_D12	T1	LCD	3V3	out	
	out	3V3	LCD	T2	LCD_D13	27		28	LCD_D14	U2	LCD	3V3	out	
	out	3V3	LCD	U3	LCD_D15	29		30	LCD_D16	T3	LCD	3V3	out	
	out	3V3	LCD	R3	LCD_D17	31		32	LCD_D18	U4	LCD	3V3	out	
	out	3V3	LCD	T4	LCD_D19	33		34	LCD_D20	R4	LCD	3V3	out	
	out	3V3	LCD	U5	LCD_D21	35		36	LCD_D22	T5	LCD	3V3	out	
	out	3V3	LCD	R5	LCD_D23	37		38	GPIO0_24	R6	GPIO	3V3	bi	
		5V	POWER		VCC5V	39		40	GPIO0_6	U6	GPIO	3V3	bi	
		5V	POWER		VCC5V	41		42	GPIO0_27	P7	GPIO	3V3	bi	
		0V	POWER		GND	43		44	GPIO0_4	T7	GPIO	3V3	bi	
		0V	POWER		GND	45		46	GPIO3_6	K5	GPIO	3V3	bi	
	bi	3V3	GPIO	N9	GPIO0_17	47		48	GPIO0_26	P6	GPIO	3V3	bi	
	bi	3V3	SD_CARD	U8	SD_D0	49		50	GPIO0_7	T6	GPIO	3V3	bi	
	bi	3V3	SD_CARD	R8	SD_D2	51		52	GPIO0_16	N7	GPIO	3V3	bi	
	bi	3V3	SD_CARD	N8	SD_CMD	53		54	GPIO0_5	R7	GPIO	3V3	bi	
	in	3v3	SD_CARD	L9	SD_WP	55		56	SD_D1	T8	SD_CARD	3V3	bi	
	out	3V3	SD_CARD	P8	SD_SCK	57		58	SD_D3	U7	SD_CARD	3V3	bi	
	in	3V3	UART1	L4	AUART1_RX	59		60	SD_DETECT#	N6	SD_CARD	3V3	in	
	in	3V3	UART3	M5	AUART3_RX	61		62	AUART1_TX	K4	UART1	3V3	out	
	out	3V3	UART3	K6	AUART3_RTS#	63		64	AUART3_TX	L5	UART3	3V3	out	
	in	3V3	CAN1	M9	CAN1_RX	65		66	AUART3_CTS#	L6	UART3	3V3	in	
	out	3V3	CAN1	M7	CAN1_TX	67		68	PWM4	E10	PWM	3V3	out	
	out	3V3	LCD/PWM	K8	LCD_BACKLIGHT_PWM	69		70	PWM3	E9	PWM	3V3	out	
	out	3V3	DUART	L7	DUART_TX	71		72	DUART_RX	K7	DUART	3V3	in	
10 kΩ ↑	bi	3V3	I2C1	H7	I2C1_SDA	73		74	I2C1_SCL	H6	I2C1	3V3	bi	10 kΩ ↑
	in	3V3	UART0	G5	AUART0_RX	75		76	AUART0_TX	H5	UART0	3V3	out	
	out	3V3	UART0	J7	AUART0_RTS#	77		78	AUART0_CTS#	J6	UART0	3V3	in	
		0V	POWER		GND	79		80	GND		POWER	0V		

4.1.1.2 Module connector X2

Table 6: Pin assignment module connector X2

PU/PD	I/O	Level	Usage	i.MX28 pin	Name	Pin		Pin	Name	i.MX28 pin	Usage	Level	I/O	PU/PD
		0V	POWER		GND	1		2	GND		POWER	0V		
	out	3V3	1588	B1	1588_Event2_out	3		4	1588_Event2_in	C1	1588	3V3	in	
	out	3V3	1588	D1	1588_Event3_out	5		6	1588_Event3_in	E1	1588	3V3	in	
	in	3V3	UART	C2	AUART4 RX	7		8	AUART4 TX	A2	UART	3V3	out	
	out	3V3	UART	B2	AUART4 RTS#	9		10	AUART4 CTS#	D2	UART	3V3	in	
	out	3V3	SPI	A3	SSP2_SCK	11		12	SSP2_MISO	B3	SPI	3V3	in	
	out	3V3	SPI	C3	SSP2_MOSI	13		14	SSP2_SS0	C4	SPI	3V3	out	
	out	3V3	ENET	F3	ENET_FEC_RESET_B#	15		16	DEBUG	B9	CONFIG	3V3	in	10 kΩ ↑
		0V	POWER		GND	17		18	GND		POWER	0V		
	out	3V3	ENET	G4	ENET_MDC	19		20	ENET_CLK	E2	ENET	3V3	out	
	bi	3V3	ENET	H4	ENET_MDIO	21		22	ENET_INT	E3	ENET	3v3	in	
	in	3V3	ENET0	H1	ENET0_RXD0	23		24	ENET0_TXD0	F1	ENET0	3v3	out	
	in	3V3	ENET0	H2	ENET0_RXD1	25		26	ENET0_TXD1	F2	ENET0	3v3	out	
	in	3V3	ENET0	E4	ENET0_RX_EN	27		28	ENET0_TX_EN	F4	ENET0	3V3	out	
	in	3V3	ENET1	J3	ENET1_RX_EN	29		30	ENET1_TX_EN	J4	ENET1	3V3	out	
	in	3V3	ENET1	J1	ENET1_RXD0	31		32	ENET1_TXD0	G1	ENET1	3V3	out	
	in	3V3	ENET1	J2	ENET1_RXD1	33		34	ENET1_TXD1	G2	ENET1	3V3	out	
		0V	POWER		GND	35		36	GND		POWER	0V		
	out	3V3	USB1	F6	USB_1_PWR_EN	37		38	USB_1_DM	B8	USB1	5V	bi	
	in	3V3	USB1	D3	USB_1_OVERCURRENT	39		40	USB_1_DP	A8	USB1	5V	bi	
	out	3V3	USB0	F5	USB_0_PWR_EN	41		42	USB_0_DM	A10	USB0	5V	bi	
	in	3V3	USB0	D4	USB_0_OVERCURRENT	43		44	USB_0_DP	B10	USB0	5V	bi	
		0V	POWER		GND	45		46	GND		POWER	0V		
	in	3V3	USB0	J5	USB_0_ID	47		48	CAN0_RX	L8	CAN0	3V3	in	
	in	3V3	CONFIG	A11	PSWITCH	49		50	CAN0_TX	M8	CAN0	3V3	out	
10 kΩ ↑	bi	3V3	I2C0	C7	I2C0_SCL	51		52	I2C0_SDA	D8	I2C0	3V3	bi	10 kΩ ↑
	out	3V3	SPDIF	D7	SPDIF	53		54	GPIO2_9	D10	GPIO	3V3	bi	
	out	3V3	I2S/AUDIO	E7	SAIF0_SDATA0	55		56	SAIF1_SDATA0	E8	I2S/AUDIO	3V3	in	
	bi	3V3	I2S/AUDIO	F7	SAIF0_BITCLK	57		58	SAIF0_LRCLK	G6	I2S/AUDIO	3V3	bi	
	out	3V3	I2S/AUDIO	G7	SAIF0_MCLK	59		60	RESET#	A14	CONFIG	3V3	in	10 kΩ ↑
		0V	POWER		GND	61		62	GND		POWER	0V		
	in	3V3	Touch/ADC	C14	LRADC6	63		64	HSADC0	B14	ADC	3V3	in	
	in	3V3	Touch/ADC	D13	LRADC4	65		66	LRADC5	D15	Touch/ADC	3V3	in	
	in	3V3	Touch/ADC	C8	LRADC2	67		68	LRADC3	D9	Touch/ADC	3V3	in	
	in	3V3	ADC	C15	LRADC0	69		70	LRADC1	C9	ADC	3V3	in	
10 kΩ ↑	in	3V3	JTAG	D12	JTAG_TMS	71		72	JTAG_TCK	E11	JTAG	3V3	in	10 kΩ ↑
10 kΩ ↑	in	3V3	JTAG	E12	JTAG_TDI	73		74	JTAG_TRST#	D14	JTAG	3V3	in	10 kΩ ↑
		4V2	POWER	A15	Battery	75		76	JTAG_RTCK	E14	JTAG	3V3	out	10 kΩ ↑
		4V2	POWER	A15	Battery	77		78	JTAG_TDO	E13	JTAG	3V3	out	
		0V	POWER		GND	79		80	GND		POWER	0V		

4.2 System components

4.2.1 Processor

The Freescale processor i.MX28 (MCIMX287CVM4B) based on the ARM926EJ-S™ core is produced in 90 nm technology. It provides a wide range of functions. Illustration 2 gives an overview. More information about the i.MX28 processor is provided in the following table.

Table 7: Processor information

Manufacturer	Part number	Temp.-range	Package	Silicon revision
Freescale	MCIMX287CVM4B	–40 °C to +85 °C	BGA 289	1.2

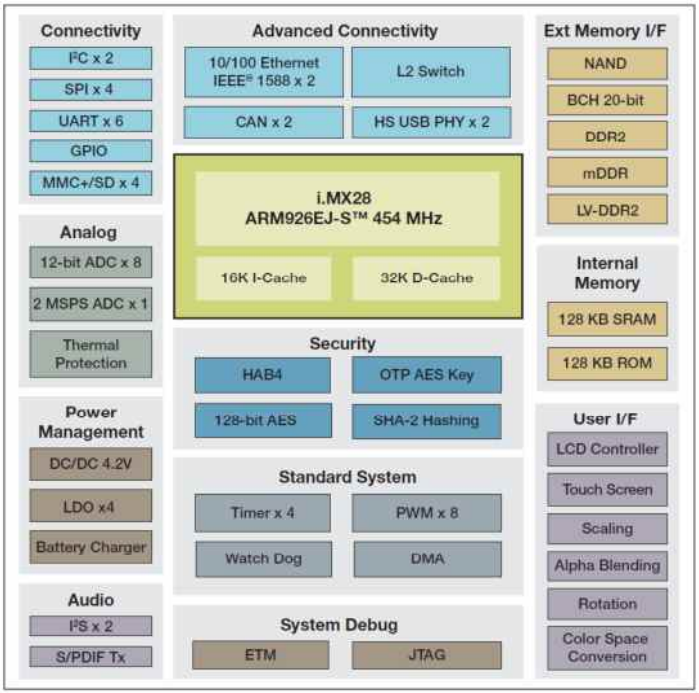

Illustration 2: i.MX28 block diagram
(Source: Freescale)

Key functionalities

ARM926EJ-S CPU:

- I-Cache, D-Cache, L2-Cache
- Integrated SRAM
- CPU Clock: 454 MHz
- DDR2

User interfaces

- LCD controller (up to 24-bit-per-pixel WVGA)
- Touch interface (4-wire / 5-wire)
- Graphics support (scaling, rotation, alpha blending, colour space conversion)

Interfaces:

- 2 × USB 2.0 Hi-Speed Host interface (USB0 is OTG capable)
- 2 × FlexCAN modules
- 2 × configurable SPI, 2 × SSI/I^2S, 5 × UART, MMC/SDIO, 2 × I^2C
- 2 × Ethernet (with IEEE® 1588 extension)

Package:

- BGA-289

Other functionality of the processor shown in the block diagram can be looked up in the Reference Manual.
All essential pins of the processor, except the DDR2 SDRAM interface and the eMMC, are routed to the module connectors.

4.2.1.1 Boot modes

After a reset the boot mode of the i.MX28 is configured in a boot sequence by reading the voltage levels of the boot mode pins. The following table shows the relevant pins as well as the assignment of the matching resistors. On the TQMa28 the eMMC boot mode (SD/MMC Master on SSP0 3V3) is fixed.

Table 8: Configurable boot pins on the TQMa28

Pin	Function name	Boot mode name	Function	Configuration resistors	
				10 kΩ PU	10 kΩ PD
K2	LCD_D0	BM0	Boot mode select	R13	–
K3	LCD_D1	BM1	Boot mode select	–	R17
L2	LCD_D2	BM2	Boot mode select	–	R16
L3	LCD_D3	BM3	Boot mode select	R14	–
M2	LCD_D4	Voltage Select	Boot mode select	–	R15

To boot from another source rather than the module-internal eMMC flash, the boot default can be changed by resistors of about 1 kΩ at the pins LCD_D00 … D03.
Table 9 shows the configurations that are possible with the TQMa28.

Table 9: Boot mode configurations for the TQMa28

Volt. Sel. (LCD 04)	BM3 (LCD03)	BM2 (LCD02)	BM1 (LCD01)	BM0 (LCD00)	Port	Boot mode
X	0	0	0	0	USB0	USB
0	0	0	0	1	I²C0	I²C0 Master 3V3
1	0	0	0	1	I²C0	I²C0 Master 1V8
0	0	0	1	0	SPI2	SPI Master SSP2 boot from flash 3V3
1	0	0	1	0	SPI2	SPI Master SSP2 boot from flash 1V8
0	0	0	1	1	SPI3	SPI Master SSP3 boot from flash 3V3
1	0	0	1	1	SPI3	SPI Master SSP3 boot from flash 1V8
0	0	1	0	0	GPMI	NAND 3V3
1	0	1	0	0	GPMI	NAND 1V8
0	0	1	0	1		Reserved
0	0	1	1	0	JTAG	Wait JTAG connection mode
0	0	1	1	1		Reserved
0	1	0	0	0	SPI3	SPI master from SSP3 boot from EEPROM 3V3
1	1	0	0	0	SPI3	SPI master from SSP3 boot from EEPROM 1V8
0	**1**	**0**	**0**	**1**	**SSP0**	**SD/MMC master on SSP0 3V3 (default)**
1	1	0	0	1	SSP0	SD/MMC master on SSP0 1V8
0	1	0	1	0	SSP1	SD/MMC master on SSP1 3V3
1	1	0	1	0	SSP1	SD/MMC master on SSP1 1V8
0	1	0	1	1		Reserved
0	1	1	0	0		Reserved
0	1	1	0	1		Reserved
0	1	1	1	0		Reserved
0	1	1	1	1		Reserved

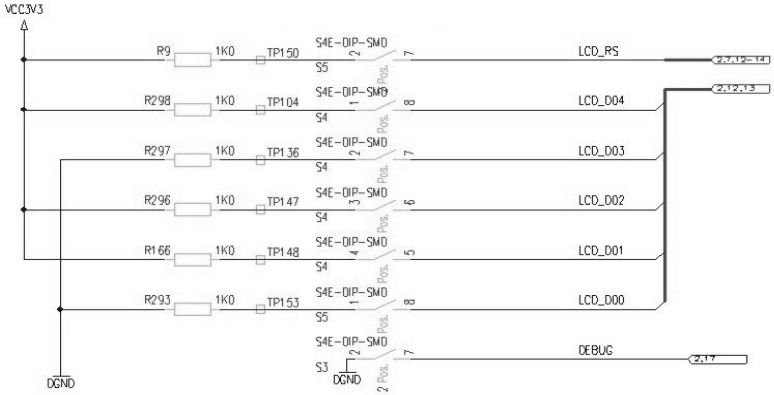

Illustration 3: Example of low impedance overriding the boot source

In addition to signals LCD_D00 … D04 signals LCD_RS and debug can also be overridden with low-impedance resistors.
With LCD_RS = H can be switched to the boot setting LCD_D00 … D04, if the boot mode is set by the internal OTP eFuses (HW_OCOTP_ROM7:0x8002C210:0 = 1).
The signal DEBUG = L switches the boundary scan on.

4.2.1.2 Processor clock supply

The processor requires two external clock signals, which are supplied via the inputs RTC_XTAL and XTAL. A crystal oscillator at the input XTAL supplies a frequency of 24 MHz.
A 32.768 kHz crystal oscillator is connected to the input RTC_XTAL.
All other clock signals required by the CPU are generated from the 24 MHz clock by the processor-internal PLL. The clock at RTC_XTAL supplies the CPU-internal clock.

4.2.1.3 Memory management

The TQMa28 is equipped with DDR2 SDRAM.
The start address of the SDRAM is 0x40000000.
The eMMC flash is not managed by this architecture.

4.2.1.4 Pin multiplexing

Depending on the configuration, the pin multiplexing enables different pins to have different functions. Freescale provides on their website the program “IOMUXCC“, which supports the selection of the desired options.
The information in this manual corresponds to the signals used on the Starter Kit STK-MBa28 and their support in the BSP.
TQ-Systems provides an xml file created with the program "IOMUXCC", which shows the pin-multiplexing of the TQMa28. The user can configure specific pin-multiplexing based on this xml file. The xml file can be obtained from TQ-Systems Support.
The accuracy of the generated configuration cannot be guaranteed!
It is the user's responsibility to conscientiously check the generated configuration.

Attention: Destruction or malfunction!	
	Many of the CPU pins can be used in several different ways. Please, notice the notes about the wiring of these pins in the i.MX28 Reference Manual before integration / start-up of your carrier board / Starterkit.

4.2.1.5 CPU errata

Attention: Malfunction!	
	Please pay attention to the latest errata of the Freescale CPU.

4.2.2 Memory

4.2.2.1 DDR2 SDRAM

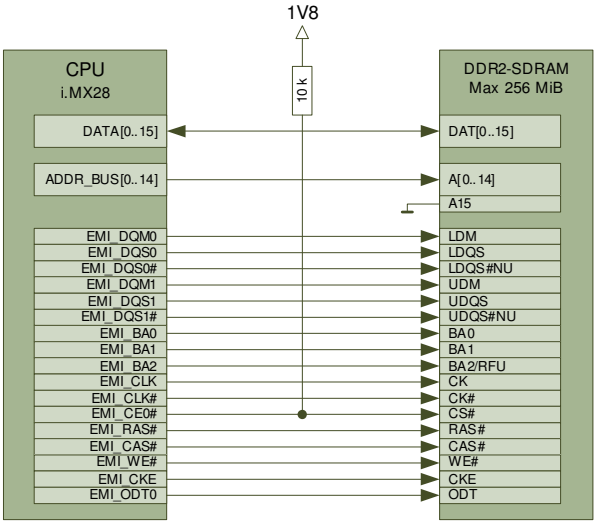

Illustration 4: Interface to DDR2 SDRAM

The memory provided by Micron is assembled as the standard component.

Attention: Hynix alternative!	
	If the Hynix SDRAM is assembled the temperature range of the module is reduced to 0 to +85 °C.

The following table gives an overview of the possible alternatives.

Table 10: Memory models DDR2 SDRAM

Manufacturer	128 MiB		256 MiB	Remark
	Manufacturer's number	Temperature range	Manufacturer's number	
Hynix	HY5PS1G1631CFP	0 to +95 °C		
Micron	M47H64M16HR-3IT	–40 to +85 °C	MT47H128M16 XX	Not specified

4.2.2.2 eMMC

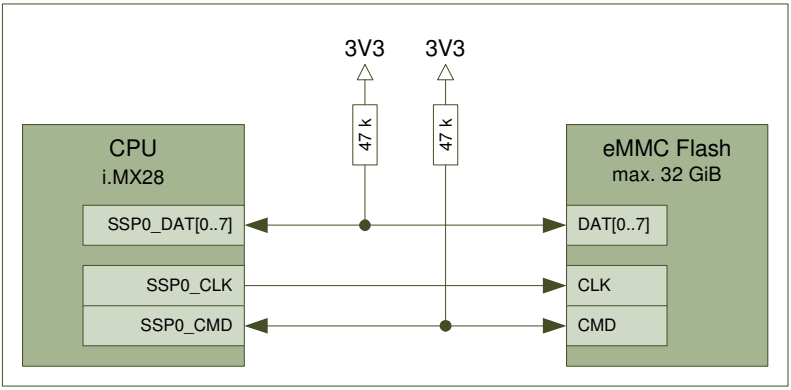

Illustration 5: Interface to eMMC

The TQMa28 is equipped with an eMMC flash. It is controlled via the SD card controller SSP0 of the i.MX28. The processor has an eMMC interface according to specification 4.4.

Table 11: Memory models eMMC flash

Manufacturer	2 GiB		
	Manufacturer's number	MMCA Rev.	Temperature
Toshiba	THGBM1G4D1EBAI7DTH	4.41	–25 to +85 °C
Toshiba	THGBM3G4D1FBAIG	4.3	–25 to +85 °C
SanDisk	SDIN5D1-2G-T	4.41	–25 to +85 °C

The temperature range of the eMMC determines the lower temperature limit of the module.

4.2.2.3 EEPROM

For permanent storage of e.g. module characteristics or customers parameters a serial 64 Kibit EEPROM is provided. The EEPROM is controlled via I^2C bus 1 of the processor.
Detailed information concerning the I^2C-address configuration can be found in section 4.2.9.2.
The writing protection (WP) of the EEPROM is not available.

Table 12: Memory model EEPROM

Manufacturer	Manufacturer's number
ST Microelectronics	M24C64-WDW6TP

4.2.3 RTC

The TQMa28 provides a processor internal RTC.
The current consumption of the RTC is approximately 10 µA.
A 32.768 kHz crystal oscillator clocks the RTC.

In the following table the parameters of the crystal oscillator are shown.

Table 13: Parameters of 32.768 kHz crystal oscillator

Parameter	Value	Unit	Remark
Frequency tolerance versus temperature	±20	ppm	25 °C
Frequency ageing	±3 max.	ppm	First year, @ 25 °C
Parabolic Coefficient	-0.04×10^{-6}	$°C^2$	Additional deviation at temp ≠ 25°C

When the power supply is switched off the internal RTC has to be buffered by a lithium-ion battery to maintain its function.
The internal RTC is supplied from the processor and has no dedicated power supply pin.
If the characteristics of the internal RTC are not suitable, the DS1339 is proposed as an external RTC on the carrier board.

4.2.4 Temperature sensor

A National Semiconductor LM73 temperature sensor is provided. The sensor is placed on the topside of the module (see D6 in Illustration 14). The interface of the sensor is shown in section 4.2.9.2. The “Alert”-output of the sensor including a 10 kΩ pull-up at the processor (pin GPIO0_16) is optionally available. By default the connection is not present.

4.2.5 SD card

The TQMa28 provides an SD card controller (SSP1), which is available at the module connector X1. Different devices can be connected.

Table 14: SD card interface

CPU i.MX28 Signal name	SD card / microSD card	eMMC 8 bit	Remark
SD_SCK	CLK	CLK	
SD_CMD	CMD/DATA IN	CMD	No PU on the TQMa28
SD_DETECT#	CARD DETECT[4]		No PU on the TQMa28
SD_WP	WRITE PROTECT[5]		No PU on the TQMa28
SD_D0	DATA0/DATA OUT	DATA0	No PU on the TQMa28
SD_D1	DATA1	DATA1	No PU on the TQMa28
SD_D2	DATA2	DATA2	No PU on the TQMa28
SD_D3	DATA3/CD	DATA3	No PU on the TQMa28
GPIO0_4		DATA4	No PU on the TQMa28
GPIO0_5		DATA5	No PU on the TQMa28
GPIO0_6		DATA6	No PU on the TQMa28
GPIO0_7		DATA7	No PU on the TQMa28

Attention: Usage of the SD interface	
	The pull-up resistors, which are required for the operation of the SD interfaces, must be implemented on the carrier board.

[4] The function is tied to the SD card socket and possibly not always available.
[5] The function is tied to the SD card socket and not available with microSD cards.

4.2.6 Graphics interfaces / LCD bus

Parallel displays with a maximum frame size of up to 800 × 480 pixels can be connected to the TQMa28. The parallel data interface can be up to 24 bits wide.

The LCD bus is directly routed to the module connector.

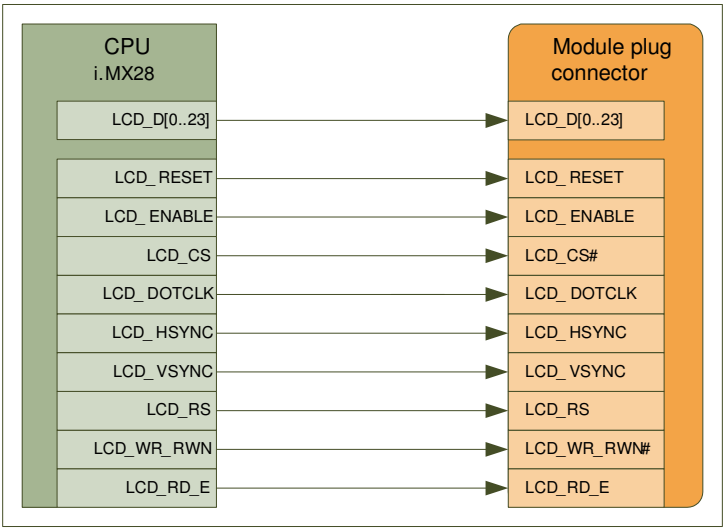

Illustration 6: Interface to the LCD

4.2.7 USB

Two USB-High-Speed interfaces are available on the TQMa28. The first (USB0) is OTG capable. The second port exclusively provides a Hi-Speed host. For both ports the PHY is integrated in the i.MX28. The 5 V supply for the USB ports has to be implemented on the carrier board. In addition, filtering and EMC protection for the USB signals has to be provided on the carrier board. Notes are to be found in the USB standard.

4.2.8 Ethernet

The i.MX28 provides two built-in Fast Ethernet controllers, which are designed for 10 and 100 Mbps.
Both provided RMII interfaces are available to the user directly at the module connectors.
The Ethernet interface is completed by a PHY on the carrier board.
The following illustration shows a circuit variant for an external Phy.
The shown LAN8720 is not assembled on the TQMa28.

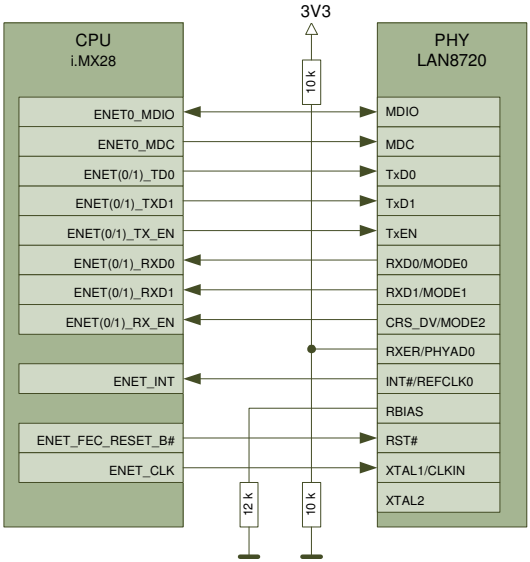

Illustration 7: Interface to the Ethernet Phy

Both controllers supply additional functions according to IEEE® 1588.
In addition to the IEEE® 1588 Ethernet signals the following signals are available at the module connectors:

- 1588_Event2_out (Freescale: EN-ETH0_1588_Event2_out)
- 1588_Event3_out (Freescale: EN-ETH0_1588_Event3_out)
- 1588_Event2_in (Freescale: EN-ETH0_1588_Event2_in)
- 1588_Event3_in (Freescale: EN-ETH0_1588_Event3_in)

By turning off pre-set functions and switching on 1588-features, more 1588_Events can be provided.

4.2.9 Serial interfaces

4.2.9.1 UART

In Hi-Speed mode the baud rate is up to 3.25 Mbit/s at 1.5 MHz XCLK.
The DUART is specified only up to 115.2 kbit.
In the default setting the following UARTs are available at the module connectors:

- AUART0 (TX, RX, CTS, RTS)
- AUART1 (TX, RX)
- AUART3 (TX, RX, CTS, RTS)
- AUART4 (TX, RX, CTS, RTS)
- DUART (TX, RX)

The UART signals are routed to the module connectors as LVTTL signals.
They may need driver's devices on the carrier board to be used as external signals.
In addition, filtering and EMC protection for the UART signals has to be provided on the carrier board.

4.2.9.2 I²C bus

The bus clock is set to 100 kHz, but can be configured up to 400 kHz by software.

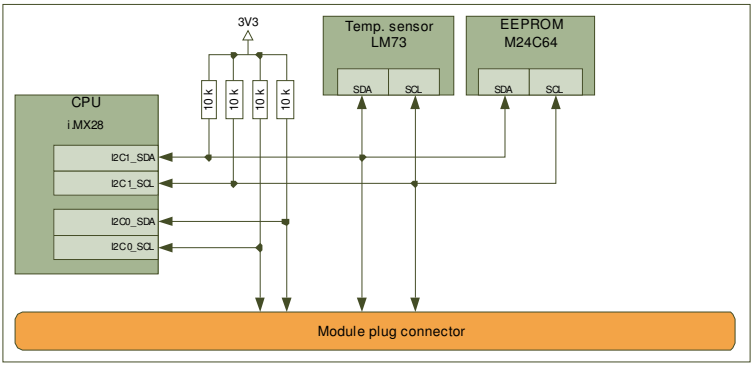

Illustration 8: Interface of the I²C buses

There are two devices with an I²C interface on the module.
Both devices are connected to I²C bus 1:

- Temperature sensor
- EEPROM

The following table shows the associated address ranges.

Table 15: I²C device configuration

Device	Device-Address							
	Hex	MSB	Binary					LSB
Temperature sensor	0x49	1	0	0	1	0 (A2)	0 (A1)	1 (A0)
EEPROM	0x50	1	0	1	0	0 (A2)	0 (A1)	0 (A0)

Attention: pull-up resistors	
	All pull-up resistors for the I²C buses are already assembled on the module and must therefore not be equipped on the carrier board. If more devices are connected the bus load has to be estimated. If necessary the overall resistance has to be reduced by additional parallel resistors.

4.2.9.3 CAN

Both CPU-internal FlexCAN controllers of the i.MX28 with data rates up to 1 Mbit/s (according to CAN 2.0B protocol) are used as CAN interfaces. The signals are routed to the module connectors. The corresponding drivers have to be provided on the carrier board.

4.2.9.4 SPI

The SPI interface of the i.MX28 is named SSP. The SSP2 interface signals (MOSI, MISO, SCK and SS0) are available at connector X2. In addition to SSP2, SSP3 can be switched alternatively to AUART4.

Table 16: Alternative SSP3 – AUART4

SSP3	AUART4
SSP3_MOSI	AUART4_RX
SSP3_MISO	AUART4_RTS
SSP3_SCK	AUART4_TX
SSP3_SS0	AUART4_CTS

4.2.10 PWM

The PWM outputs of the i.MX28 are directly available at the module connector pins.
For use with the STK-MBa28 the following alternative signals are supported in the BSP.

Table 17: PWM signals

PWM	Usage
PWM0	DUART_RX
PWM1	DUART_TX
PWM2	LCD_Backlight_PWM
PWM3	PWM3
PWM4	PWM4
PWM5	SAIF0_BITCLK
PWM6	SAIF0_SDATA0
PWM7	SAIF1_SDATA0

4.2.11 GPIO

The i.MX28 processor provides GPIO ports as a second or multiple configuration with other function units. The configuration can be taken from the Freescale Reference Manual.
Some of the GPIOs are directly named as GPIO and directly routed to the module connector.
All GPIOs are interrupt and wakeup-capable.

4.2.12 JTAG

The JTAG signals are directly routed from the CPU to the module connector.
All necessary pull-up and pull-down resistors are present on the TQMa28.

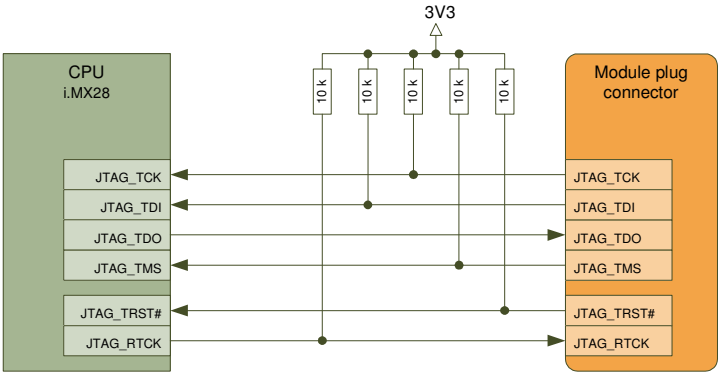

Illustration 9: JTAG interface

The additionally available signal DEBUG is pulled-up on the TQMa28.

Table 18: DEBUG function

Debug	Function
DEBUG = H	JTAG
DEBUG = L	Boundary scan

4.2.13 ADC

The TQMa28 provides eight ADC inputs. All inputs are blocked to GND with 10 nF.
The BSP supports four ADC inputs (LRADC2 … 5), if a 4-wire touch is connected.
An adequate protection circuit has to be implemented on the carrier board.

4.2.14 Audio

SPDIF, as well as the Serial Audio Interface (SAIF) is available to connect audio components. The SAIF enables to connect 3, 4 or 5-wire serial interface, e.g. I^2S.

4.2.15 Reset / PSwitch

Two sources on the carrier board are possible for a system reset of the CPU:

- Power-on reset
- RESET# (e.g. reset push button)
  reset is triggered after a valid low signal >100 ms with a following rising edge

The JTAG_TRST # (e.g. JTAG debugger) works as a software reset during development.
Depending on the applied level PSWITCH has different functions. For function description see (1).
It is important to note that PSWITCH voltages of 2.45 V to 3.3 V are not critical, since a 10 kΩ series resistor protects the input. If the TQMa28 remains permanently connected to a battery power supply via the battery pin, it must be switched on with PSWITCH. Similarly, the PSWITCH can also be used for shut down.
If the PSWITCH shut down function is not required (high-low edge <15 ns), it can be blocked with a low pass by hardware.

The following illustration shows the PSWITCH and RESET wiring.

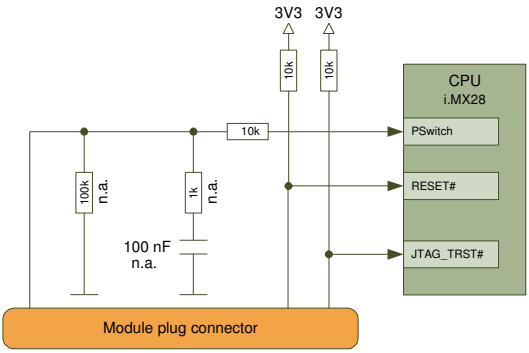

Illustration 10: Reset concept block diagram

Attention: Low-pass	
	The PSWITCH low-pass is not assembled by default.

4.2.16 Power management

The TQMa28 works with a single supply of 5 V that must be provided by the carrier board.
Alternatively a lithium-ion battery can supply the TQMa28.
In the following table the data of the supply voltage is shown.
The calculated current consumption (worst case) is at most 0.4 A.
The current consumption strongly depends on component placement, software and wiring options.

Table 19: Supply voltages

Parameter	Min.	Typ.	Max.	Unit
Supply voltage $V_{IN\ standard}$	4.75	5	5.25	V
Supply voltage $V_{IN\ battery}$	3.1	–	4.2	V

Table 20: Current consumption

Parameter	V_S	Unit	Min.	Typ.	Max.	Unit
Current consumption standby	3.3	V	–	11.0	–	mA
Current consumption standby	5.0	V	–	8,6	–	mA
Current consumption in reset	5.0	V	–	20.5	–	mA
Current consumption in Linux idle mode	5.0	V	–	140	–	mA
Current consumption in Linux idle mode	3.3	V	–	140	–	mA
Current consumption in Linux boot mode	5.0	V	–	220	–	mA
Current consumption in Linux boot mode	3.3	V	–	220	–	mA
Current consumption of internal RTC	>1.3	V	–	10	–	µA

4.2.16.1 Implementation of power rails

In combination with additional circuitry the i.MX28 generates all internal required supply voltages, as well as the associated power sequencing.

4.2.16.2 Internal power supply

The internal power supply consists of a chain of linear regulators and a DC/DC converter.
At 5 V power supply the DC/DC converter is not switched on by hardware, but must be switched on in the boot process. The DC/DC converter starts automatically in battery mode.
This means that during the boot process with 5 V only the linear regulators, which provide a maximum of 270 mA, are available. The DC/DC converter must be switched on to ensure a reliable supply even in a worst-case scenario. The TQ U-Boot, as well as Linux switch on the DC/DC converter at 5 V.

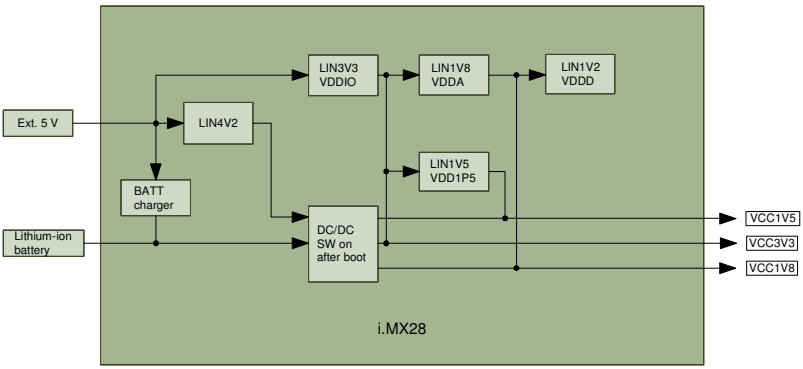

Illustration 11: Internal power supply of i.MX28, block diagram

4.2.16.3 Power-up

The module switches itself on if it is powered with 5 V.
The module does not switch itself on but has to be switched on with a positive edge at the PSWITCH pin, if it is supplied via the "battery" pin.

4.3 Lithium-ion secondary battery

The lithium-ion battery is charged if the module is supplied with 5 V. Software settings can be done in the registers HW_LRADC_CONVERSION and HW_POWER_CHARGE. The battery buffers the RTC. Details can be taken from the Reference Manual (1).

Attention: Lithium primary batteries and lithium-ion secondary batteries	
	Lithium primary batteries may not be used!

5. SOFTWARE SPECIFICATION

The TQMa28 is supplied with a boot loader and a BSP for the Starterkit STK-MBa28.
More information can be found in the Support Wiki for the TQMa28.

6. MECHANICS SPECIFICATION

6.1 General information

Dimensions (W x D):	40 × 26 mm²
Mounting holes:	None
Maximum stack height:	Max. 1.5mm (top side) / typ. 3.75 mm (bottom side)
Board to board distance:	Selectable by different mating plugs (standard: 5 mm), see also 4.1
Component placement:	Double-sided SMD component placement
Connection to carrier board:	SMD connector (pitch: 0.8 mm), see also 4.1

The information in the drawing are values without tolerances.

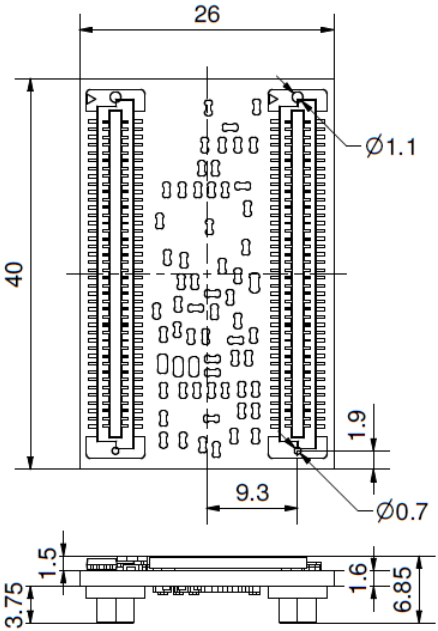

Illustration 12: Overall dimensions (bottom view, side view)

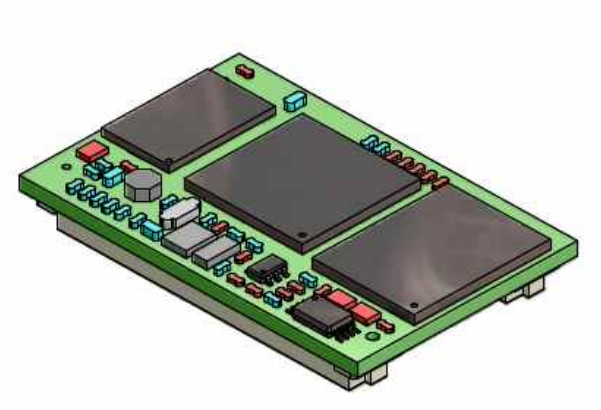

Illustration 13: 3D image of TQMa28

6.2 Notes of treatment

To avoid damages caused by mechanical stress, the TQMa28 may only be extracted from the carrier board by using the extraction tool MOZI28. It can also be obtained separately.

Attention: Note with respect to the component placement of the carrier board	
	2.5 mm should be kept free on the carrier board, along the longitudinal edges on both sides of the module for the extraction tool MOZI28.

6.3 Component placement

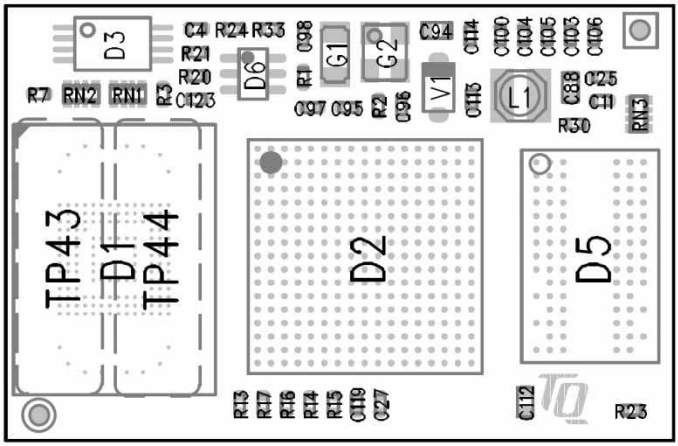

Illustration 14: Component placement top

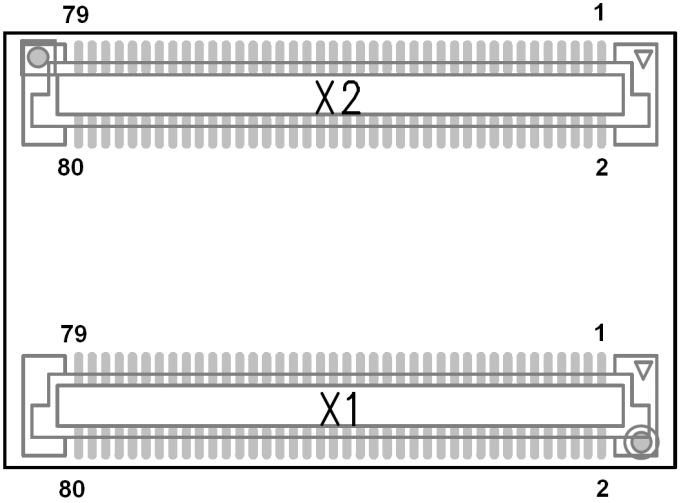

Illustration 15: Connector placement bottom

6.4 Requirements for the superior system

6.4.1 Protection against external effects

As an embedded module it is not protected against dust, external impact and contact (IP00).
An adequate protection has to be guaranteed by the surrounding system.

6.4.2 Thermal management

Up to 2 W (worst case) have to be dissipated to cool the TQMa28.
The power dissipation originates primarily in the processor and in the DDR2 SDRAM.
The thermal resistance of the module is 20 K/W.
The user is responsible for the removal of this power dissipation in his application.
In most cases a passive cooling should be sufficient.
In a warm environment (above approx. 40 °C) it can be necessary, to install the TQMa28 "on end" (module connectors vertical), to enable a flow of air on both sides of the module for passive cooling.

Attention: Destruction or malfunction!	
	The CPU belongs to a performance category with which in certain applications cooling can become necessary. It is the task of the user, to define a heat sink suitable for the specific case of operation (e.g., by clock frequency, stack height and airflow).

6.4.3 Structural requirements

The TQMa28 is held in the module socket by the retention force of the pins (a total of 160). For high requirements with respect to vibration and shock firmness an additional plastic module holder has to be provided in the final product to hold the module in its position.
For this purpose TQ-Systems provides a standard solution.
As no heavy and big components are used, no further requirements are given.

7. SAFETY REQUIREMENTS AND PROTECTIVE REGULATIONS

7.1 EMC

The module was developed according to the requirements of electromagnetic compatibility (EMC). Depending on the target system, anti-interference measures may still be necessary to guarantee the adherence to the limits for the overall system.
Following measures are recommended:

- Robust ground planes (adequate ground planes) on the printed circuit board
- A sufficient number of blocking capacitors in all supply voltages
- Fast or permanent clocked lines (e.g., clock) should be kept short;
  avoid interference of other signals by distance and/or shielding besides,
  notice not only the frequency, but also the signal rise times
- Filtering of all signals which can be connected externally
  (also "slow signals" and DC can radiate RF indirectly)

7.2 ESD

In order to avoid interspersion on the signal path from the input to the protection circuit in the system, the protection against electrostatic discharge should be arranged directly at the inputs of a system. As these measures always have to be implemented on the carrier board, no special preventive measures were planned on the TQMa28.
Following measures are recommended for a carrier board:

- Generally applicable: Shielding of the inputs (shielding connected well to ground / housing on both ends)
- Supply voltages: Protection by suppressor diode(s)
- Slow signal lines: RC filtering, perhaps Zener diode(s)
- Fast signal lines: Integrated protective devices (suppressor diode arrays)

7.3 Operational safety and personal security

Due to the occurring voltages (≤5 V DC), tests with respect to the operational and personal safety haven't been carried out.

7.4 Climatic and operational conditions

Permitted component temperature:	–25 °C to +85 °C
Permitted storage temperature:	–40 °C to +125 °C
Relative air humidity (operation / storing):	10 % to 90 % (not condensing)
Protection class:	IP00
Thermal resistance of the module:	20 K/W

7.5 Reliability and service life

No detailed MTBF calculation has been done for the TQMa28.
It was designed to be insensitive to vibration and impact.
Product life limiting components like electrolyte capacitors were not used.
Middle grade connectors, which guarantee at least 100 mating cycles, were used for the module.

7.6 Environment protection

7.6.1 RoHS compliance

The TQMa28 is manufactured RoHS compliant.

- All used components and assemblies are RoHS compliant
- RoHS compliant soldering processes are used

7.6.2 WEEE regulation

The company placing the product on the market is responsible for the observance of the WEEE regulation.
To be able to reuse the product, it is produced in such a way (a modular construction) that it can be easily repaired and disassembled.

7.6.3 Other entries

By environmentally friendly processes, production equipment and products, we contribute to the protection of our environment.
The energy consumption of this subassembly is minimised by suitable measures.
Printed pc-boards are delivered in reusable packaging. Modules and devices are delivered in an outer packaging of paper, cardboard or other recyclable material.
Due to the fact that at the moment there is still no technical equivalent alternative for printed circuit boards with bromine-containing flame protection (FR-4 material), such printed circuit boards are still used.
No use of PCB containing capacitors and transformers (**p**oly**c**hlorinated **b**iphenyls).
These points are an essential part of the following laws:

- The law to encourage the circular flow economy and assurance of the environmentally acceptable removal of waste as at 27.9.94
  (source of information: BGBl I 1994, 2705)
- Regulation with respect to the utilization and proof of removal as at 1.9.96
  (source of information: BGBl I 1996, 1382, (1997, 2860)
- Regulation with respect to the avoidance and utilization of packaging waste as at 21.8.98
  (source of information: BGBl I 1998, 2379)
- Regulation with respect to the European Waste Directory as at 1.12.01
  (source of information: BGBl I 2001, 3379)

This information is to be seen as notes. Tests or certifications were not carried out with respect to that.

8. APPENDIX

8.1 References

Table 21: Further applicable documents

No.	Name	Date	Company
(1)	i.MX28 (MCIMX) Reference Manual (MCIMX28RM)	2010 - Rev. 1	Freescale

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